

ANGSA* INITIATIVE. REVISITING APOLLO AND PREPARING FOR ARTEMIS.

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and the ANGSA Science Team
March 12, 2021**

*** Apollo Next Generation Sample Analysis Initiative.**



*linking generations of lunar explorers
from Apollo to Artemis*

Origins of ANGSA

ANGSA has its origin with CAPTEM in 2009-2010.

Unopened samples Identified as a strategic knowledge gap by NASA.

I campaigned for 9 years to interest NASA HQ in studies of unopened and unexamined Apollo samples.

Visit to the JSC curation facility by NASA SMD Associate Administrator kick-started ANGSA initiative.

Is there a different pathway for running large sample-based consortia (e.g., SSERVI)?



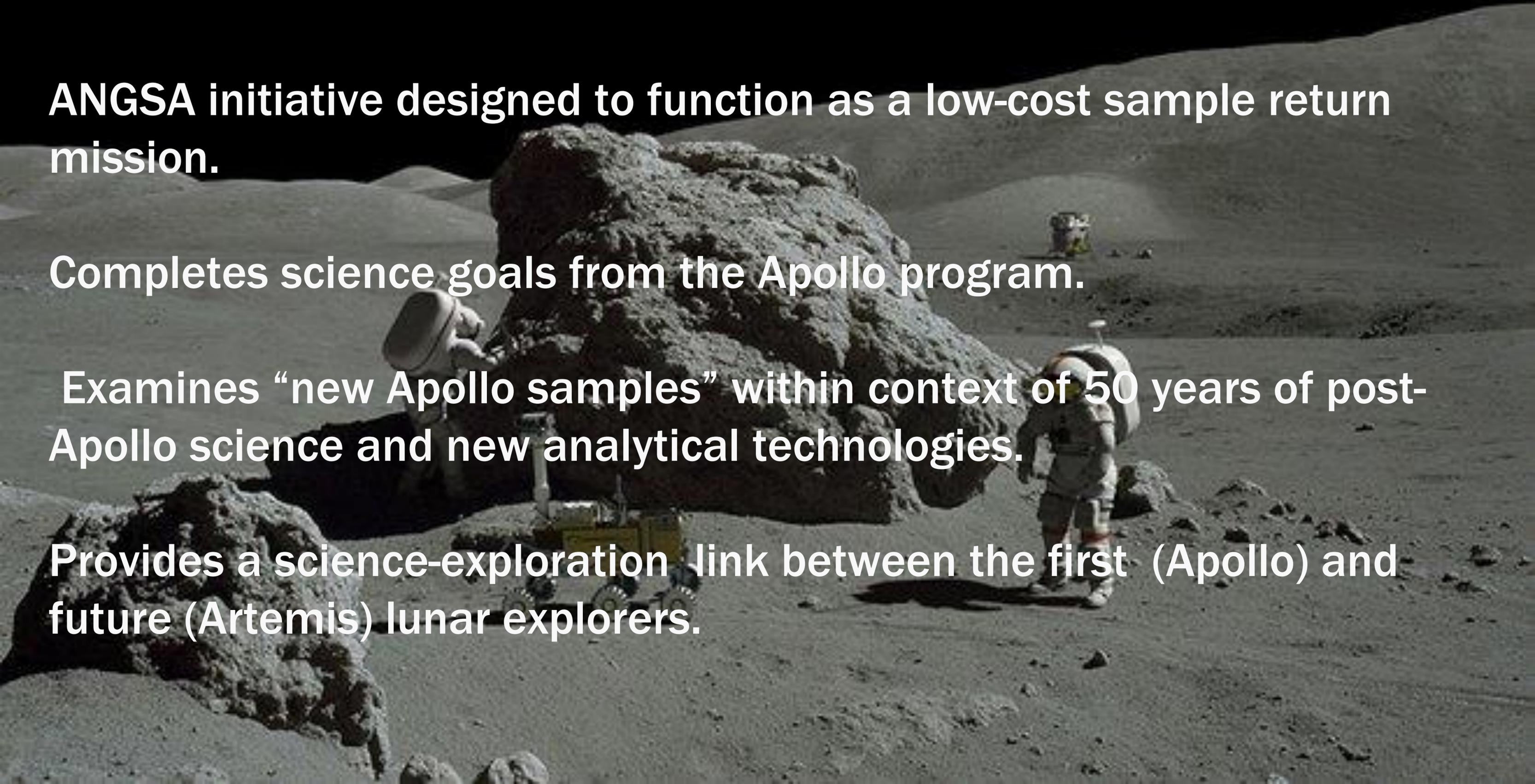
Introduction to ANGSA

ANGSA initiative designed to function as a low-cost sample return mission.

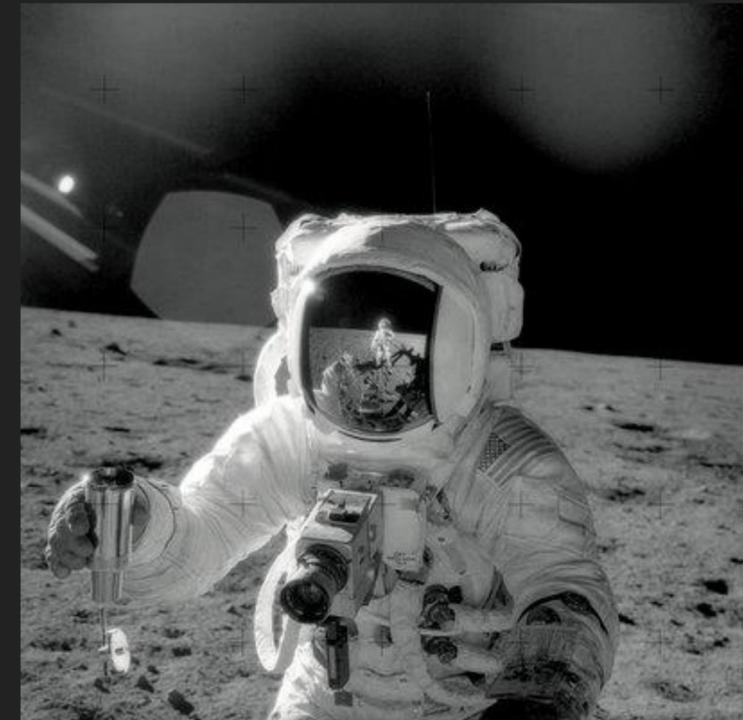
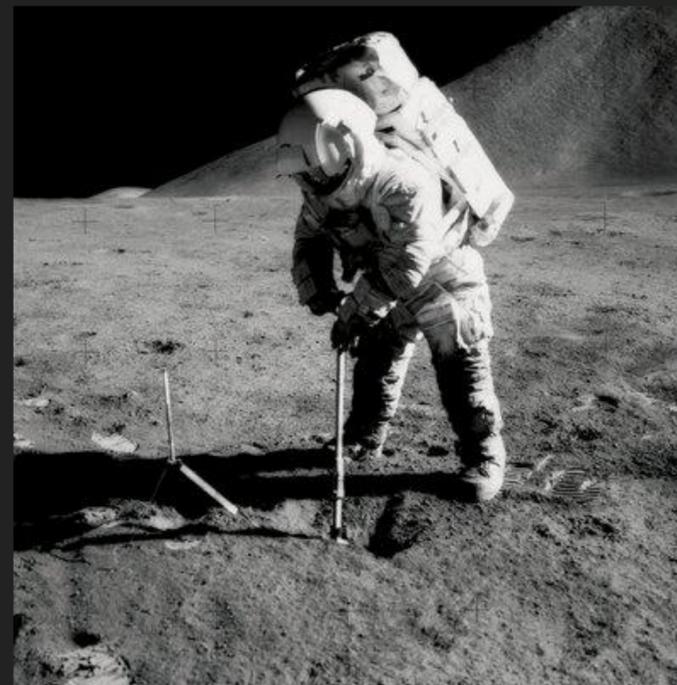
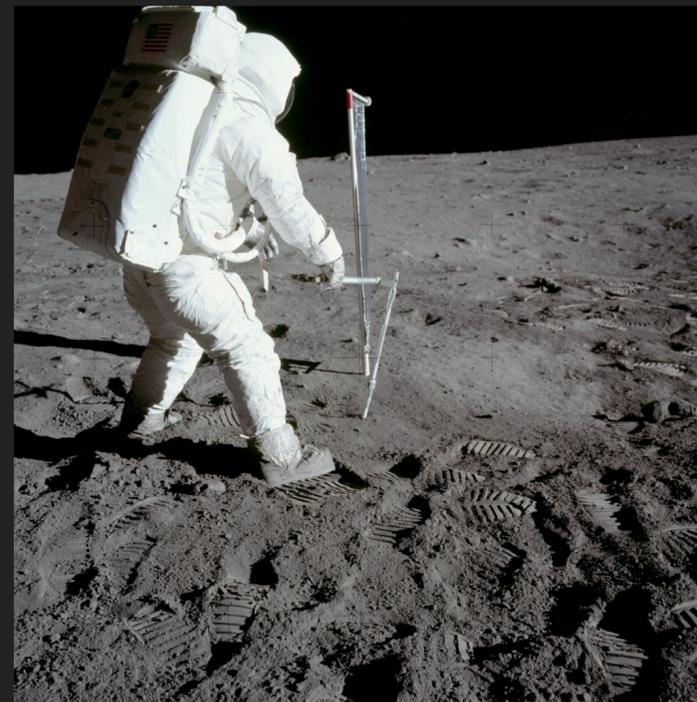
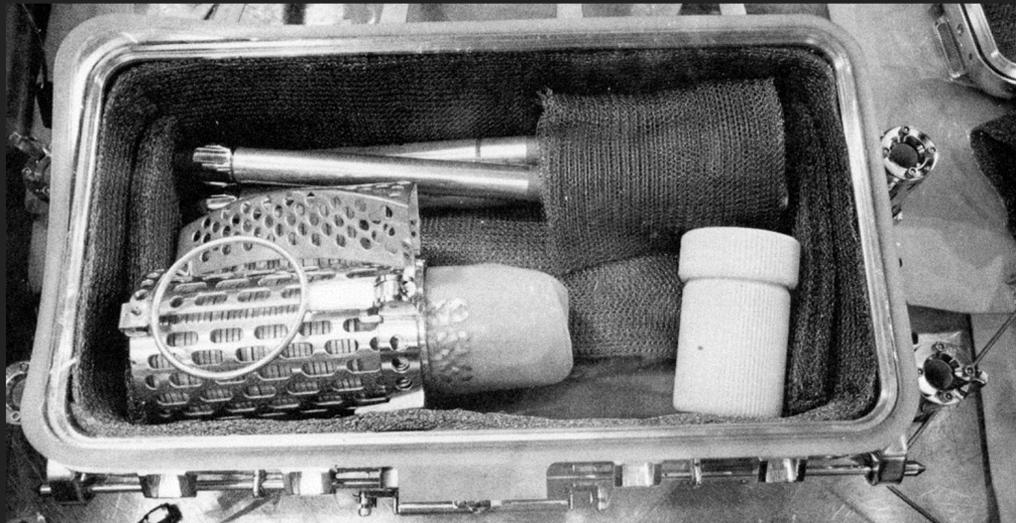
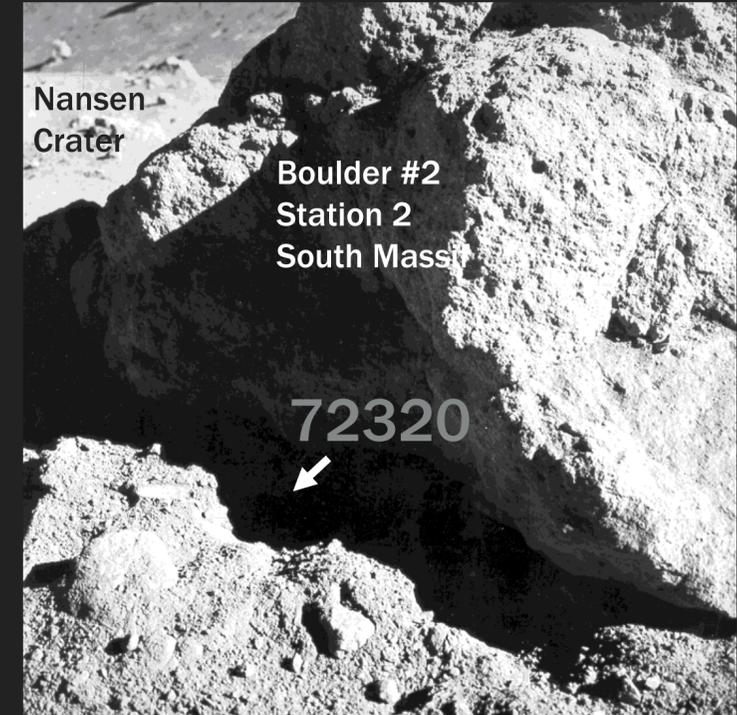
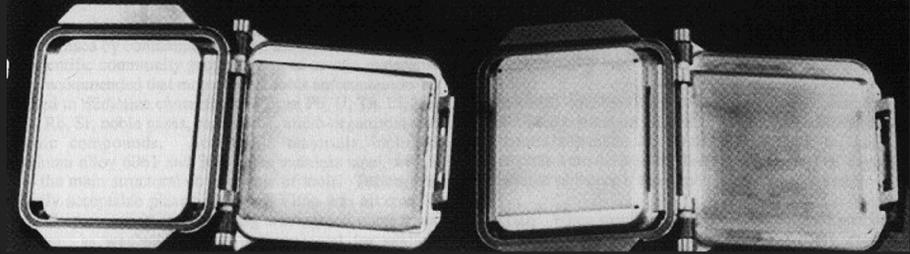
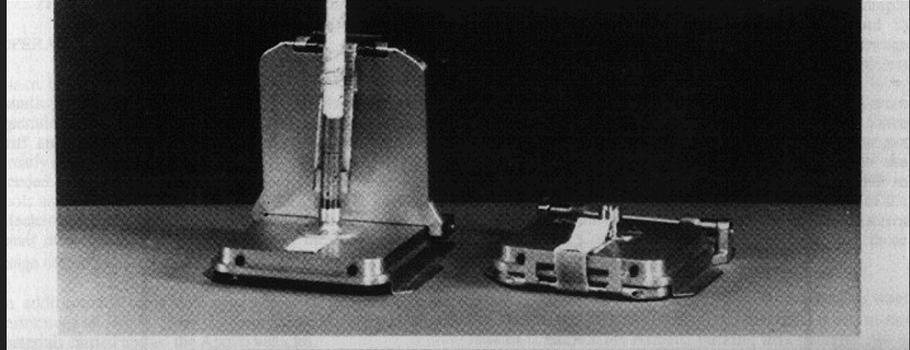
Completes science goals from the Apollo program.

Examines “new Apollo samples” within context of 50 years of post-Apollo science and new analytical technologies.

Provides a science-exploration link between the first (Apollo) and future (Artemis) lunar explorers.



Special Samples Collected by the Apollo Program



Specially Collected and Curated Lunar Samples (ANGSA)

➤ Unopened Vacuum Sealed Apollo Samples

9 “special samples” were collected in containers that had indium knife edge seals to maintain a lunar like vacuum, and 3 remain sealed: SESC 15014 (333 g), CSVC 69001 (558 g), and CSVC 73001 (809 g).

➤ Unopened Unsealed Samples

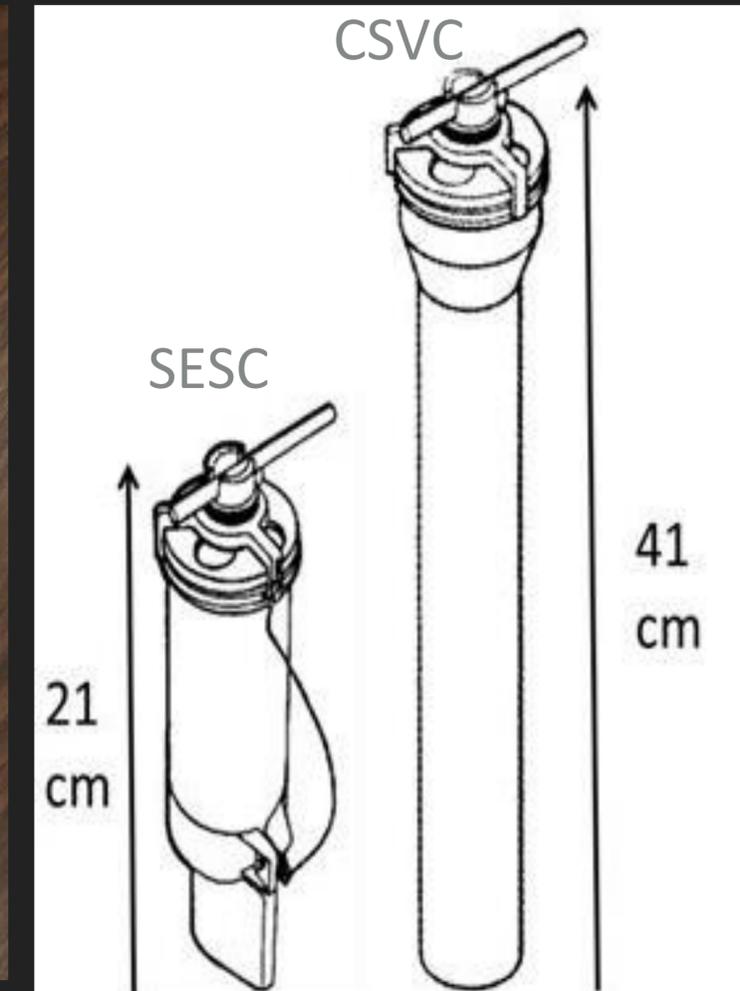
2 unopened, unsealed drive tubes: 73002 (430 g) and 70012 (485 g)

➤ Frozen Apollo Samples

A17 samples processed under nominal laboratory conditions, but placed into cold storage (-20°C) within 1 month of return: **6 Subsamples of A17 drill core**, 9 subsamples of permanently shadowed soils **72320 and 76240**, soil **70180**, and **rock 71036**.

➤ Apollo Samples stored in Helium

Apollo 15 SESC samples (**15012 & 15013**) were opened in the Univ. of California Berkeley organic clean room in a helium cabinet, and 21 subsamples of 15012 and 16 subsamples of 15013 presently (and continuously) stored in He.



Organized as a sample return mission

Nine research consortia were selected:

Jessica Barnes – University of Arizona

Katherine Burgess – Naval Research Labs

Jamie Elsila Cook – NASA Goddard

Natalie Curran & Barbara Cohen – NASA Goddard

Darby Dyar – Mount Holyoke College

Alexander Sehlke – NASA Ames

Chip Shearer – CAAAS University of New Mexico

Richard Walroth - SLAC National Accelerator Laboratory

Kees Welton – UC Berkeley



Variety of team members

UNIVERSITIES: UND, WUSTL, U of Hawaii, U of Maryland, U of Virginia, Purdue U, U of Manchester, Open University, City University London, Carnegie Institute, U of Texas, U of CO, U of Minn, U of CA Riverside

CONSULTANTS: Harrison Schmitt

NASA CENTERS: Johnson Space Center, Goddard Space Flight Center, NASA Ames.

INTERNATIONAL SPACE AGENCIES: ESA

NATIONAL LABS: LLNL, ANL, US Naval Research Lab.

RESEARCH CENTERS: Lunar and Planetary Institute, BAERI, Natural History Museum London.

Organized as a sample return mission

- **ANGSA Team Leads: Chip Shearer, Francis McCubbin**
- **Interactive team science governed by Rules of the Road document.**
- **Multiple generation Preliminary Examination Team (JSC Curation and ANGSA Science Team).**
- **Preliminary examination documents for science community.**
- **Over 60 scientists and engineers involved in ANGSA**
- **Over 20 undergraduate students, graduate students and post-docs involved in Science, Engineering, and PE.**



Apollo 17 Double Drive Tube 73001 (CSVC) and 73002 (within drive tube)

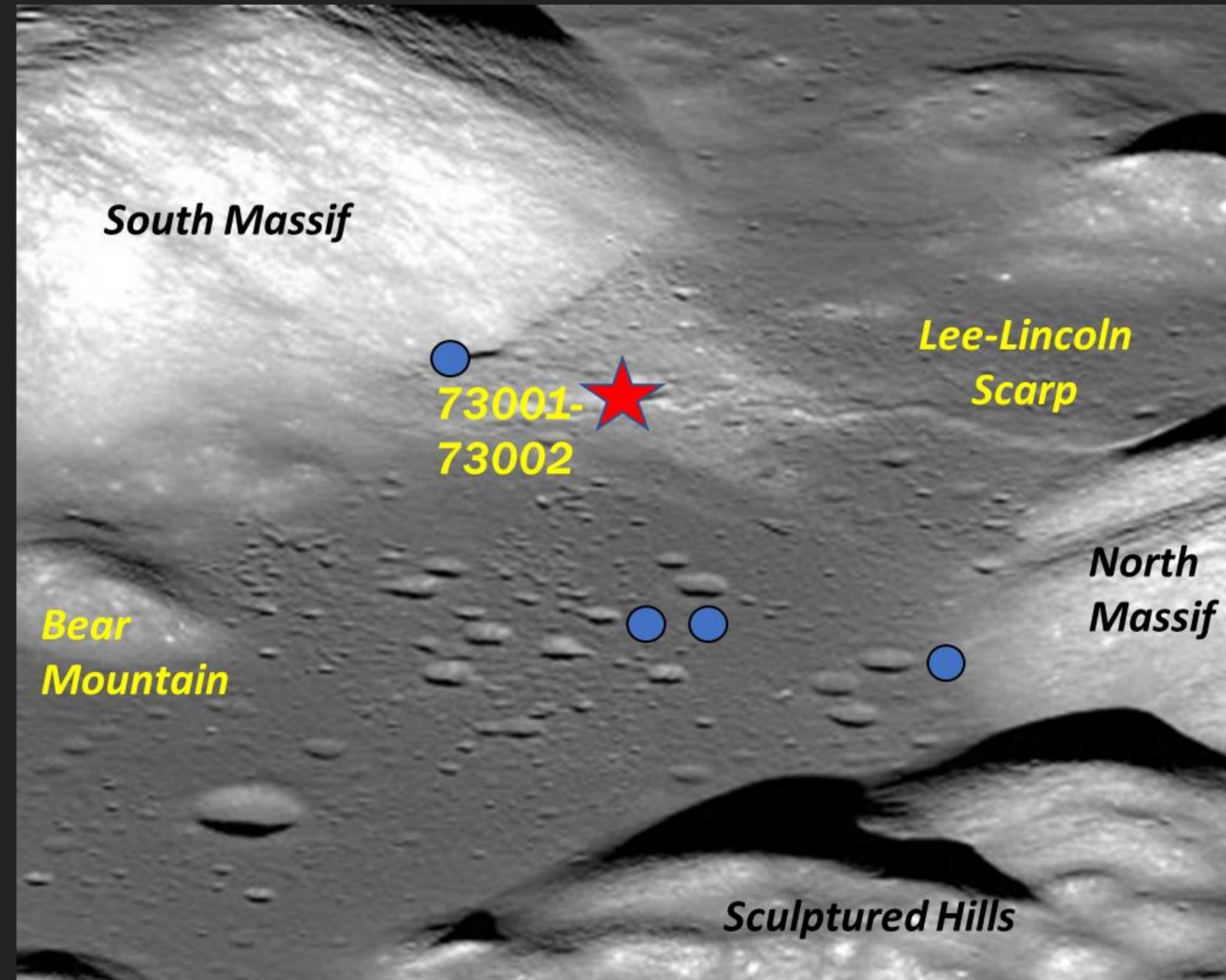
73001-73002 collected during the Apollo 17 mission to the Taurus Littrow Valley

73001-73002 is located on the light mantle approximately 50 meters east of the rim of Lara Crater. ★

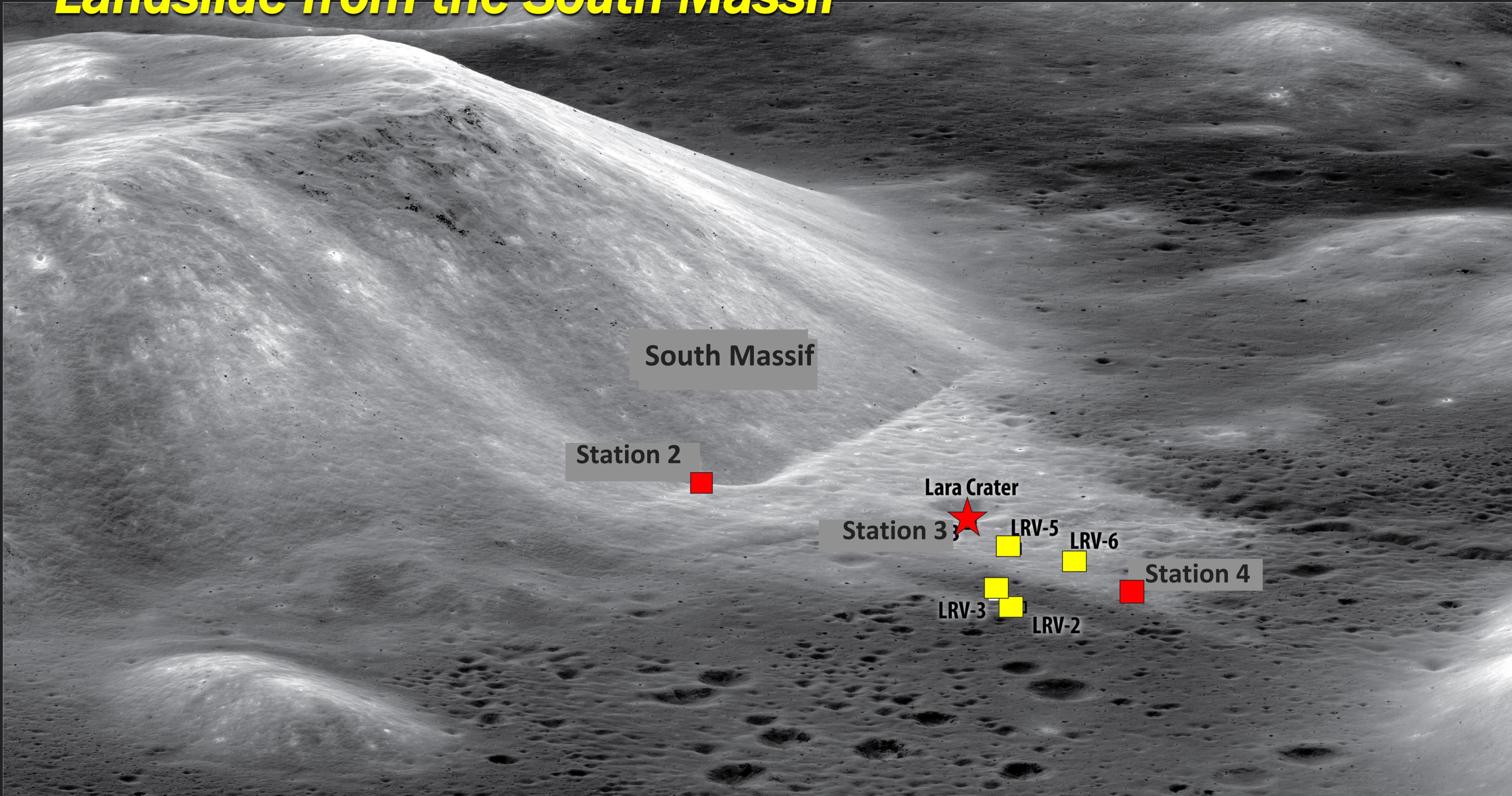
Core penetrates landslide material of the South Massif.

73001 = 809 grams, depth 70.6 ± 5 cm,
73002 = 430 grams, depth of 35.7 ± 5 cm.
Temperature approximately 250°K .

Frozen samples identified ●



Landslide from the South Massif



South Massif

Station 2



Lara Crater



Station 3



LRV-5

LRV-6

Station 4



LRV-3



LRV-2

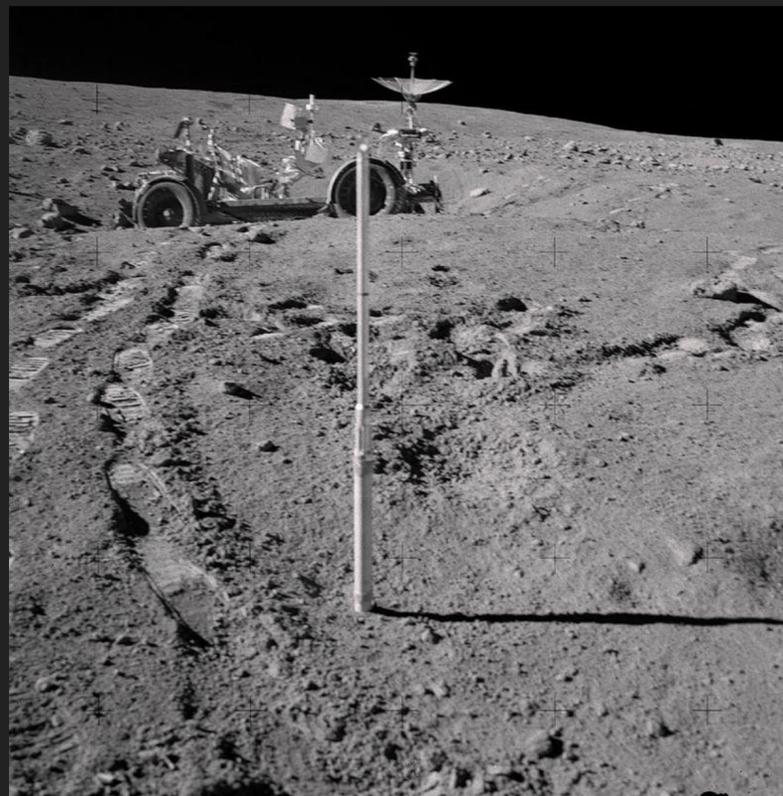
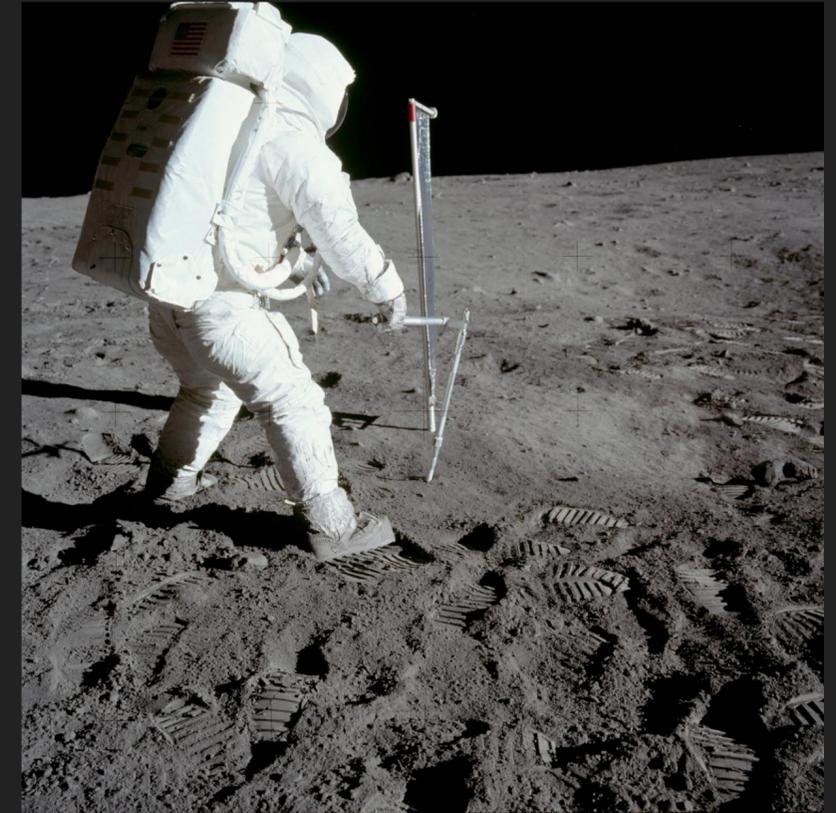
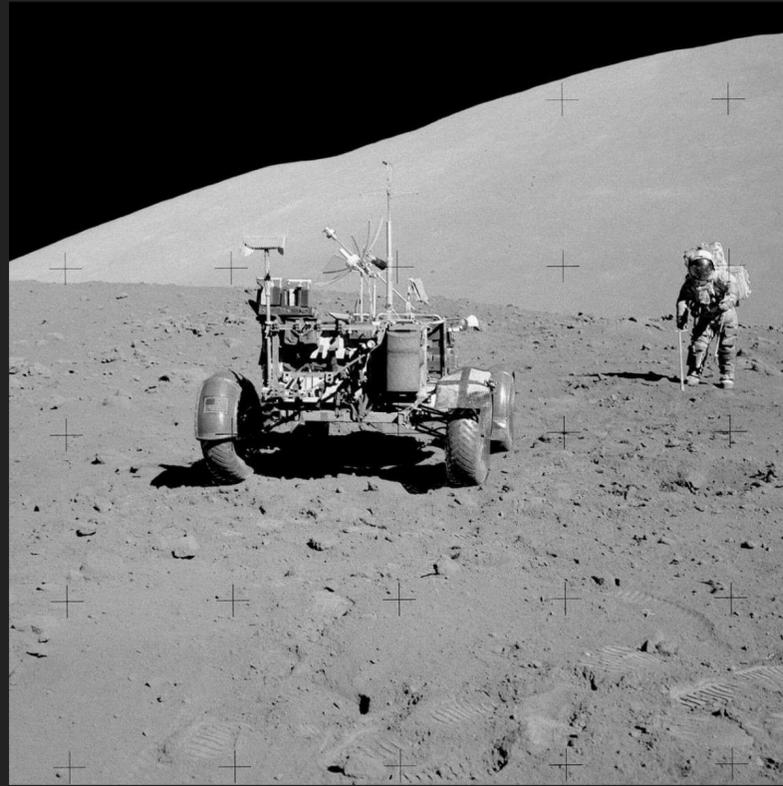


**Collecting core at
Station 3 using
double drive tube.**

Harrison Schmitt

Gene Cernan

Without original video

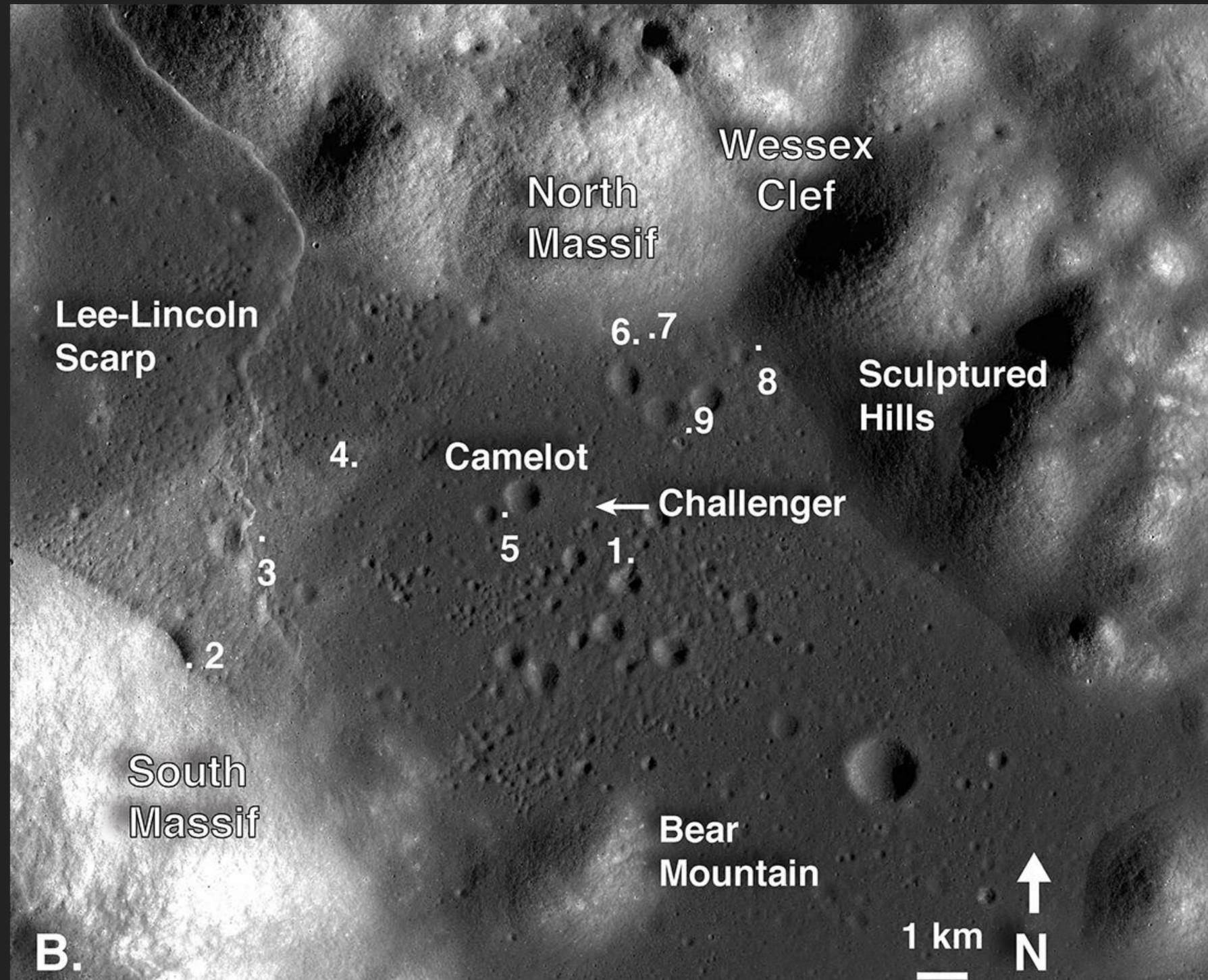


Revisiting and Fulfilling Apollo Goals

Searching for indigenous gases coming off the Lee-Lincoln Scarpe and trapped within landslide.

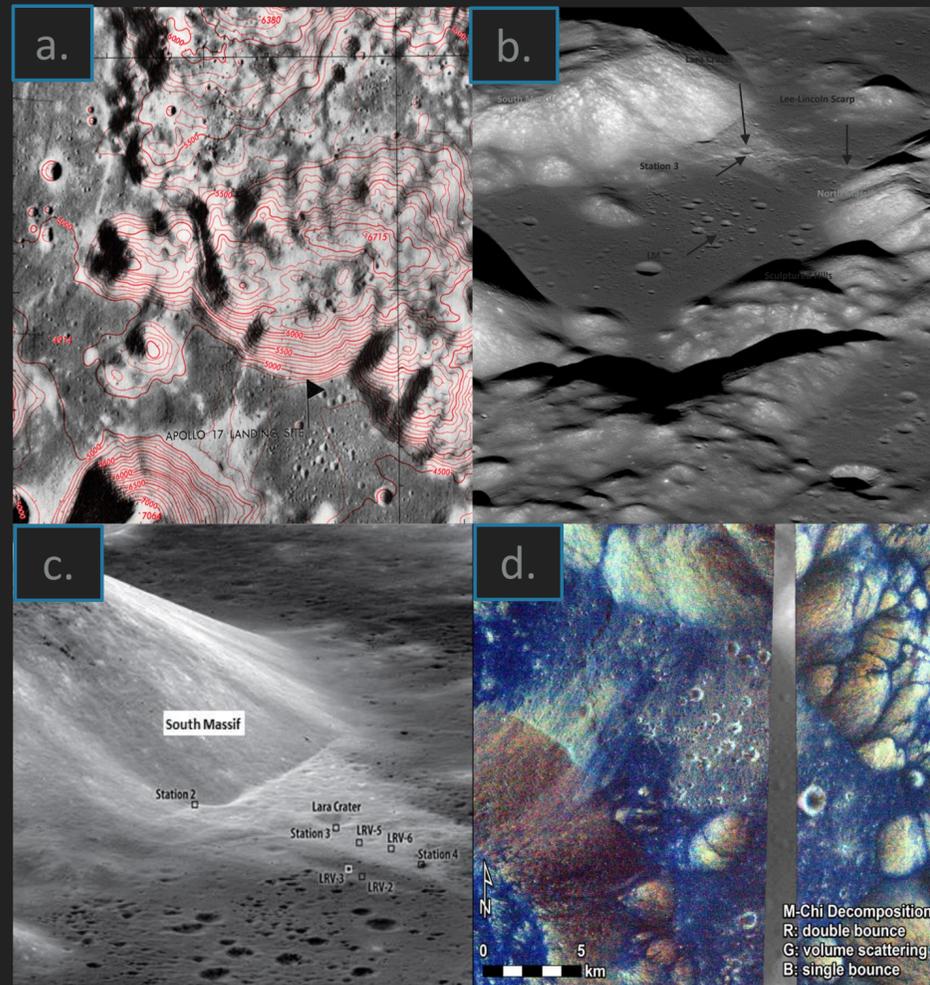
Preservation of volatiles from shadowed areas adjacent to boulders.

Without original video



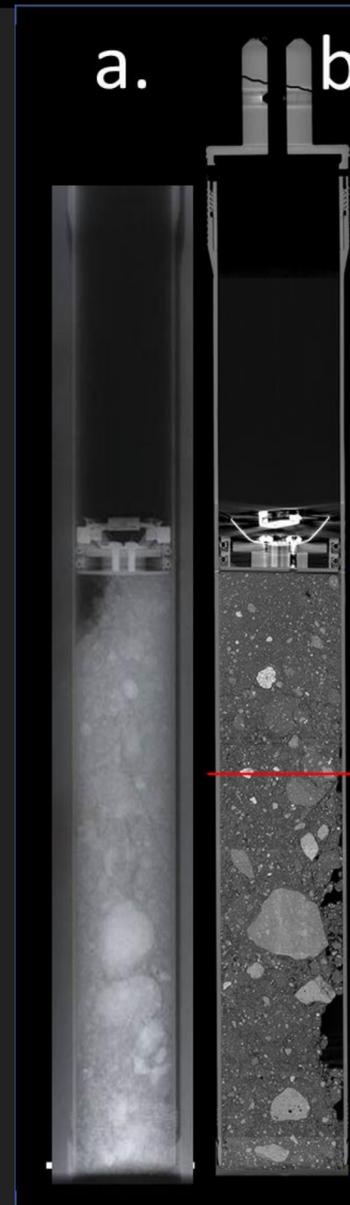
Apollo + 50 years. Examples of ANGSA Approaches and Goals

Place sampling site (A17 Station 3) into modern geologic context provide by recent lunar missions.



Without original video

Preliminary Examination (Apollo +50 years) using new tools.



X-Ray Computed Tomography (XCT) scan of core 73002

New and improved instruments and new isotopic systems.

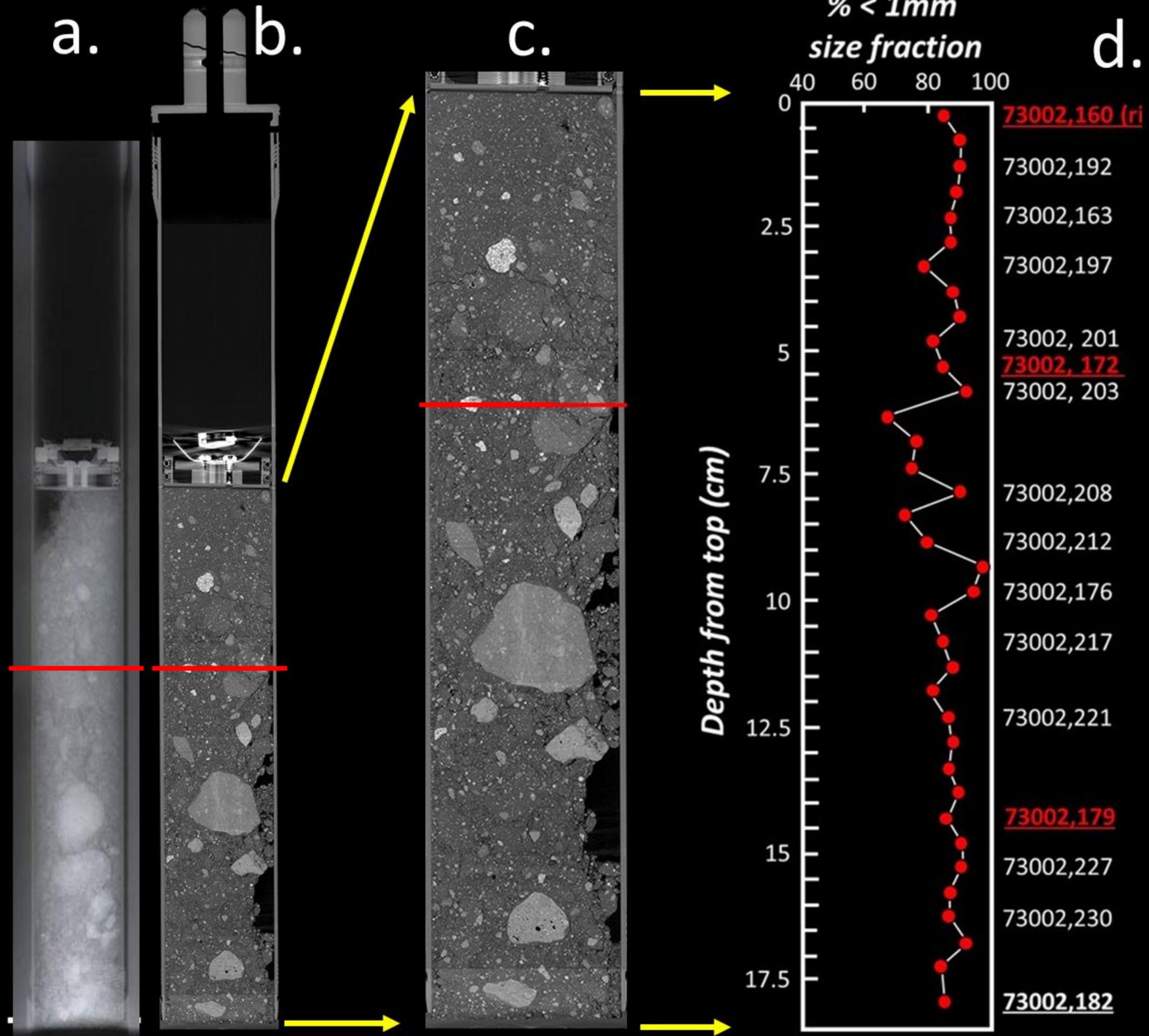
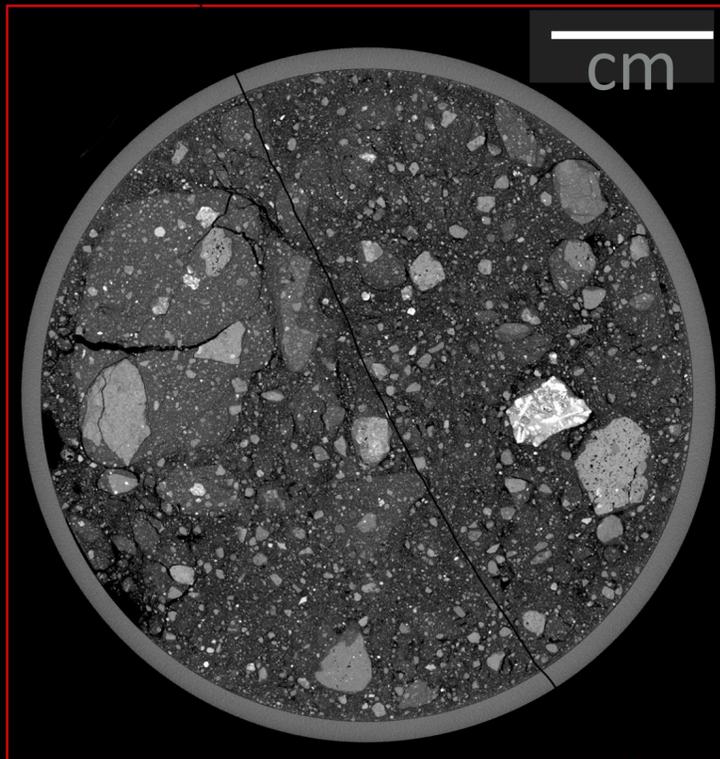


Cr redox state in lunar glasses



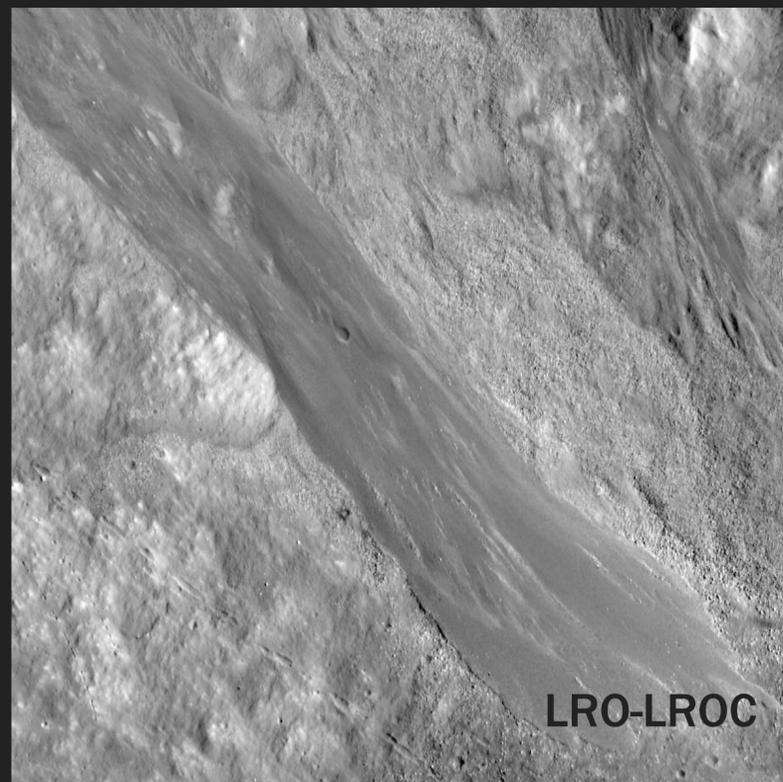
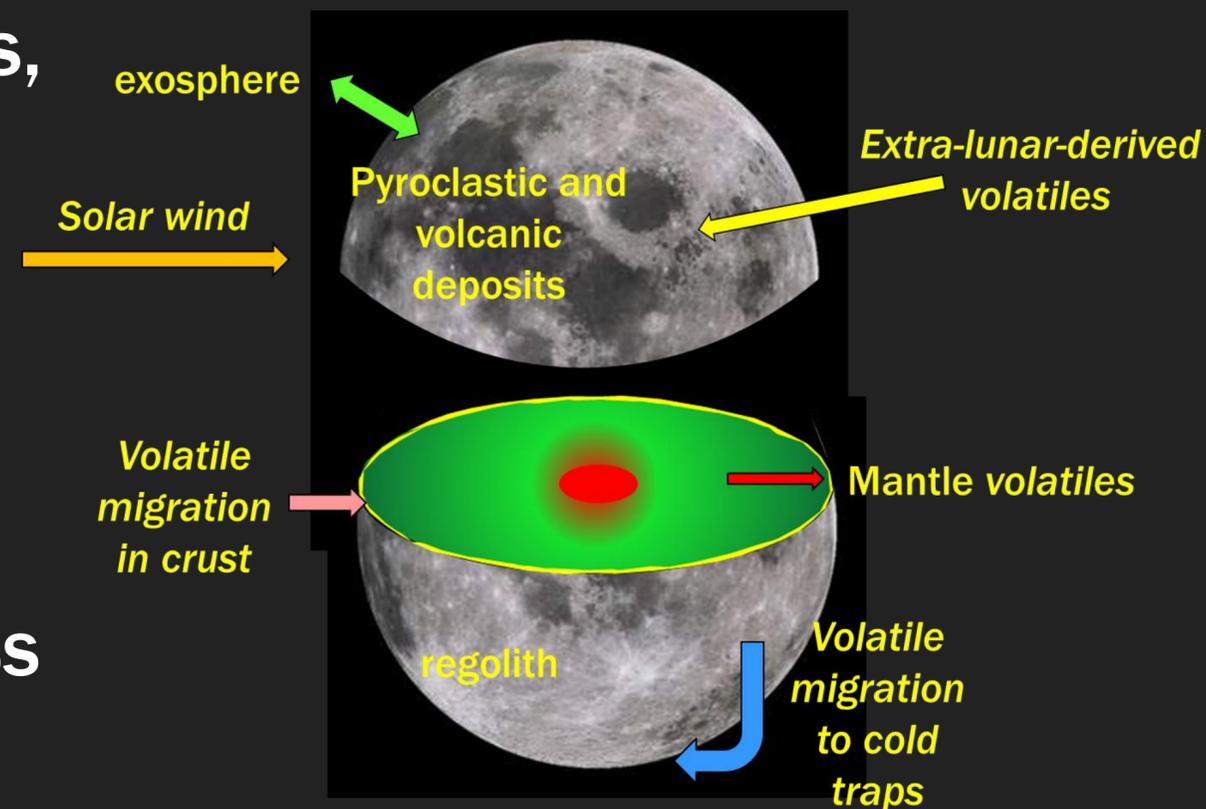
Isotopic composition of volatile elements (e.g., Cl, Zn, S, K, Pb)

PE enabling current and future science



Examples of ANGSA Science Goals

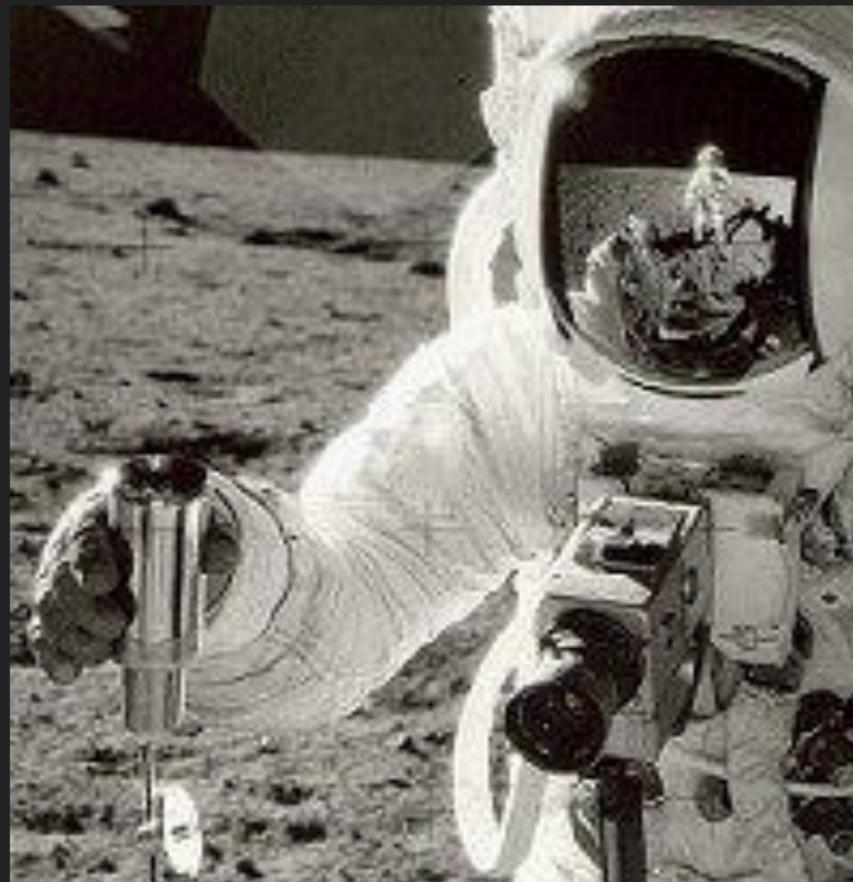
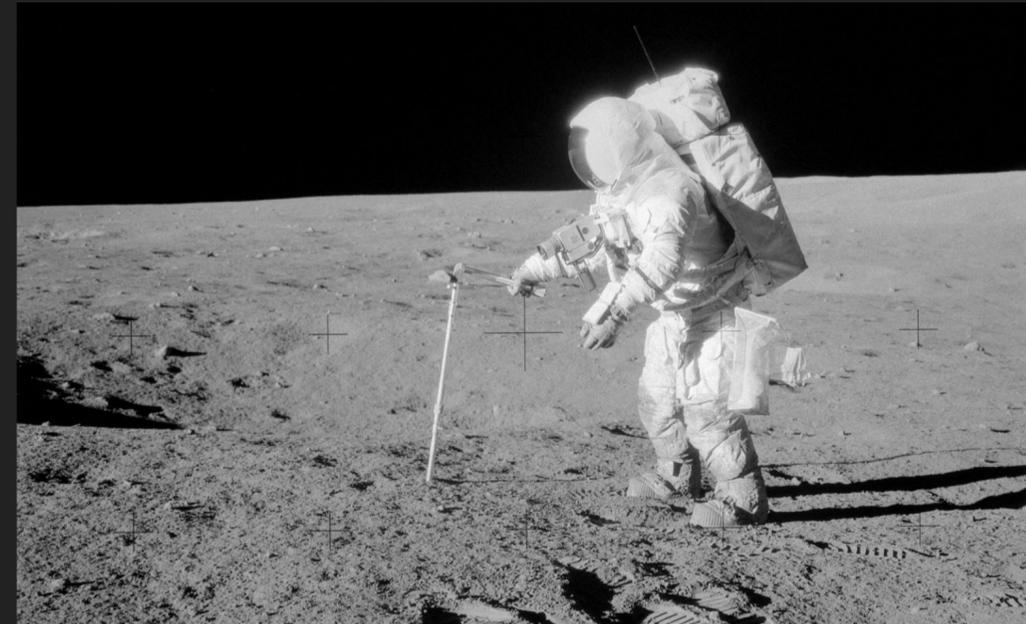
- Define the lunar volatile cycle. Distribution, sources, and preservation of volatiles.
- Define volatile element behavior in the lunar regolith.
- Define nanometer-scale processes on mineral-glass surfaces.



- Define the processes, triggers, and chronology of lunar landslide deposits.
- Define the organic cycle on the Moon and identify sources of potential organic contaminants.
- Examine the difference between sealed and unsealed samples.

Feeding forward to ARTEMIS Exploration Goals and Operations

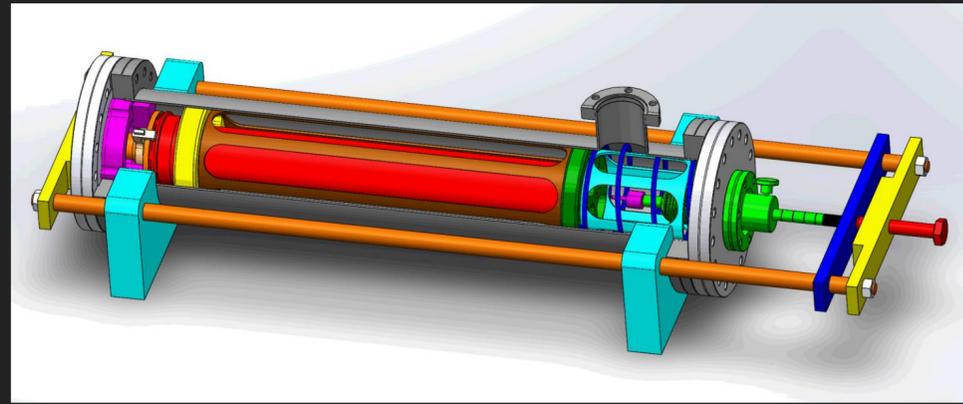
- Provide an integrated and overarching evaluation of the collection and preservation of volatile-rich samples for future exploration.
- How well did CSVC preserve sample?



- What tool improvements can be made to (a) collecting samples (b) preserving samples and (c) ease of use on the surface of the Moon?
- What improvements can be made to minimize organic contamination during (a) activities on the lunar surface, (b) curation, and (c) during sample analysis.
- Feeds forward to other sample return missions?

Apollo-ANGSA-Artemis Technology Linkages

- CSVC gas extraction system.
- Manifold (WUSTL) being built.
- CSVC piercing system (ESA) current design undergoing testing.
- Target date Summer 2021.

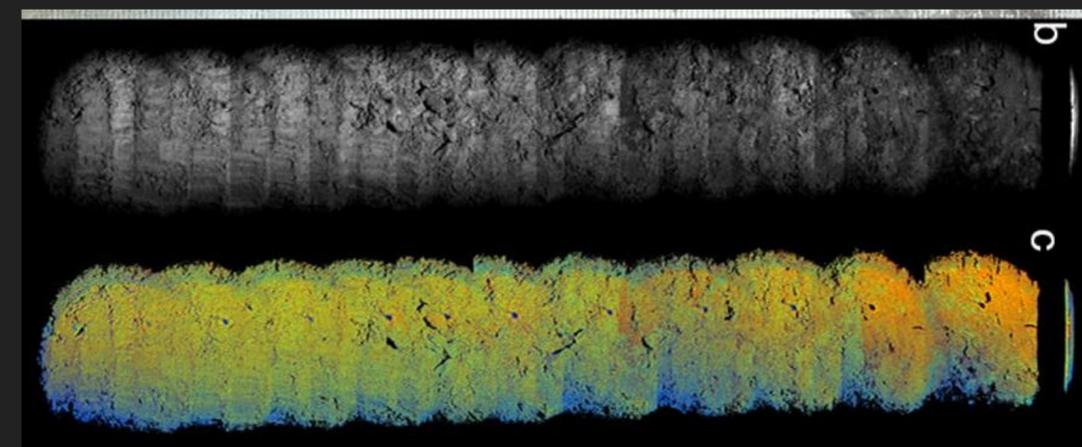


XPS (X-ray Photoelectron Spectroscopy) Vacuum Transfer Vessel.

Develop cold curation activities.

Multi-spectral analysis core tool.

Reducing and monitoring organic contamination.



ANGSA Science Summary 1

ANGSA firsts:

- Opening a specially collected core sample (Core Sample Vacuum Container CSV).
- Examining a core through a landslide deposit.
- Completing the first experiment to sample exogenous gases released from a scarp.
- First Apollo core opened since the early 1980s.
- First examination of Apollo samples frozen for almost 50 years.

ANGSA Science Summary 2

ANGSA Science Progress

- Stratigraphy and properties of core.
- O, Cl, S, H, K, Cu, Zn, Pb isotopic composition of the upper portion of the 73001-73002 double drive tube.
- Analysis of geology adjacent to Apollo 17 station 3 site.
- New curation approaches and tools to prepare for collecting lunar volatiles.
- Multi-spectral analysis of core (in situ and individual samples).
- Further processing of XCT data.
 - > 4mm lithic fragments. Crystal size distribution analysis.
 - Establish stratigraphy.
 - Model lunar landslide dynamics.
- Rare gas isotopic composition of the Moon.
- Organic measurement (samples and witness plates).
- New lunar rock-types from the South Massif.
- The influence of exposure history and mineral phase composition on the expression of space weathering features in lunar soils.
- Volatile coatings on pyroclastic glasses. Redox state of multivalent cations and anions.